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A minimal SDE model of D-O events with multiplicative noise

Kolja Kypke and Peter Ditlevsen
Physics of Ice, Climate and Earth, Niels Bohr Institute, University of Copenhagen, Denmark

The abrupt transitions in the last glacial period between cold stadial and warmer interstadial climate states found in Greenlandic ice-core records, known as Dansgaard-Oeschger (D-O) events, are a rich topic of study not only due to their potential similarities in time scales and mechanisms to present and near-future climate transitions but also since their underlying physical mechanisms are not fully understood. The dynamics of the climate can be described by a Langevin equation $dx = -\partial U/\partial x\, dt + \eta(t)$ where the potential $U(x)$ has a bimodal distribution to represent the stable stadial and interstadial states and the stochastic process $\eta(t)$ is usually realized as a Gaussian white noise process that causes jumps between these two states. From the steady-state of the Fokker-Planck equation associated with this Langevin equation, the potential $U(x)$ can be determined from the probability distribution of the ice-core record time series. Thus this minimal model simulates time series with statistics similar to those of the original ice-core record. Novel to this study, we introduce a multiplicative noise term $\eta(t, x)$ to represent the different statistical properties of the noise in the stadial and interstadial periods. The difference between the Itô and the Stratonovich integration of the Langevin equation with multiplicative noise results in slight differences in the attribution of the drift and diffusion terms for a transformed variable. This is illustrated by performing both.